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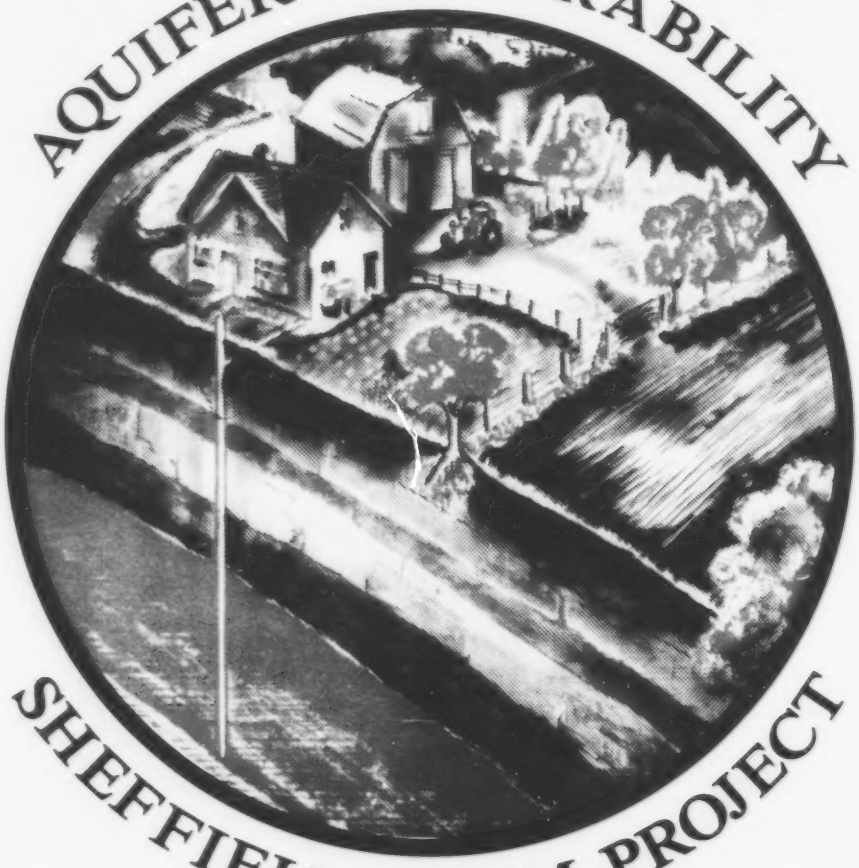

SHEFFIELD FARM PROJECT

REGIONAL WATER BALANCE

WATER RESOURCES BRANCH

CONSERVATION & PROTECTION

INLAND WATERS DIRECTORATE
ATLANTIC REGION
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SHEFFIELD FARM PROJECT

REGIONAL WATER BALANCE

Water Resources Branch
Inland Waters
Conservation and Protection
Environment Canada
Dartmouth, Nova Scotia

March 1992

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ABSTRACT

A water balance was completed for the Sharpe Brook watershed, Kings County, Nova Scotia using the BSTOR water balance model. The Sharpe Brook watershed water balance results are tested to determine the applicability of transferring this information to the Sheffield Farm research basin, Kings County, Nova Scotia.

In terms of applying the water balance model to the Sharpe Brook basin, a satisfactory and reasonable water balance was achieved on a monthly basis.

The applicability of transferring model results from Sharpe Brook to the Sheffield Farm watershed would depend upon how well the runoff values compare at the two locations. It is recommended to verify the Sharpe Brook runoff values against the measured discharge from the Sheffield Farm watershed.

1.0 INTRODUCTION

1.1 Background

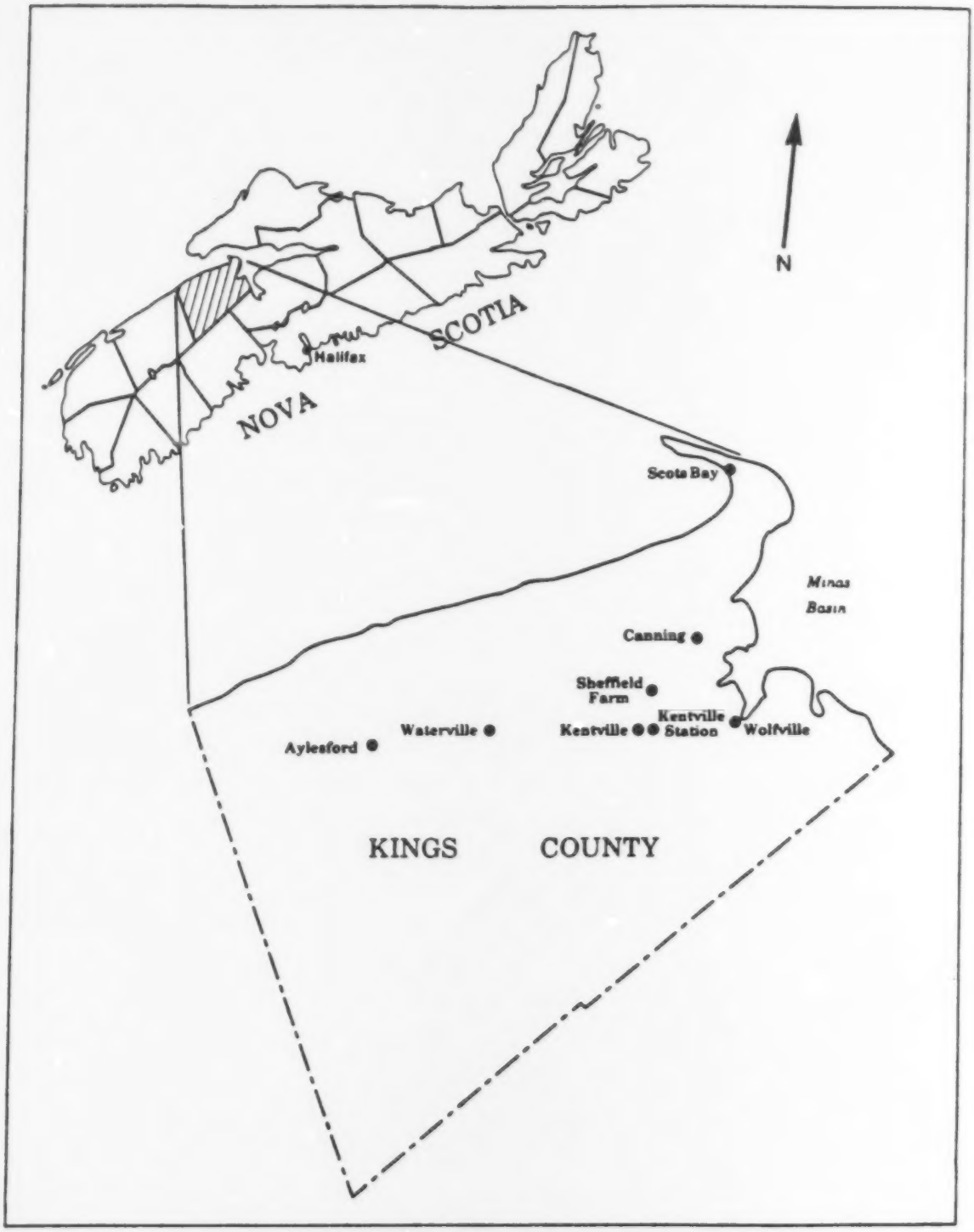
Environment Canada, in co-operation with Agriculture Canada, is leading a five year study to determine the environmental behaviour of pesticides and nitrates in the climatic, physiographic and soil conditions found in the Atlantic region. One of the goals of this project is to gain knowledge on agricultural practices which can be applied to avoid unacceptable contamination of ground water by pesticides and fertilizers. Ground water quantity and quality are monitored through a series of piezometers and lysimeters.

Although the focus of the research is on ground water and the potential impact of applied pesticides and fertilizers, there is a need to understand the overall hydrologic cycle as it occurs on and around the Sheffield Farm. The surface water component of the cycle is an integral part of movement of pesticides and fertilizers over the farm and off the farm towards downstream areas. The surface water component needs to be quantified if the ground water component (basin storage) can be understood. To better understand the hydrologic processes taking place, a water balance analysis is needed for the Sheffield Farm study.

The Agriculture Canada Sheffield Research Farm, Kings County, Nova Scotia is the site for the water balance analysis.

1.2 Study Area and Climate

The Sheffield Farm site is located five kilometres north of the Kentville Agriculture Experimental Station (see Figure 1) in the Annapolis-Cornwallis Valley of Nova Scotia. The farm is in an area that has a cool, humid climate with a total annual precipitation of over 1100 mm. Most of the precipitation falls between October and February. In the summer growing season (May, June and July) the total rainfall is over 200 mm. The average daily maximum temperatures range from 16 °C in May to 25 °C in July. The farm is located on the floor of the Annapolis-Cornwallis Valley and is bisected by an unnamed drainage channel that flows south into the main branch of the Canard River flowing into the Minas Basin.



GENERAL LOCATIONS OF THE KENTVILLE RESEARCH STATION AND SHEFFIELD FARM (AFTER LANGILLE, 1987)

FIGURE 1

1.3 Study Objective

The main objective of this report is to conduct a regional water balance of the Sheffield Farm study area based on the best information (hydrometric and climatic) available. This information would be useful to the aquifer vulnerability study by providing sub-basin water budget knowledge. Another secondary benefit of the water balance study would be the integration of AES and IWD interests in the application and interpretation of recorded data and contribute to the understanding of significant water resources needs.

1.4 Study Scope

The extent of this study is to perform a regional water balance analysis, on a monthly time frame, to provide the best estimate of basin change in storage of ground water for the Sheffield Farm study area. The water balance analysis is to be based entirely on available data. The water balance analysis should be verified using information (surface water quantity data) from or near the Sheffield Farm study area, as part of this report, or under separate cover. The water balance analysis should be performed using an existing PC based computer model.

2.0 WATER BALANCE MODEL

2.1 Model Selection

The computer model selected to carry out the water balance was program BSTOR, Analysis of Basin Storage and Water Balance with Climatological Estimate of Areal Evapotranspiration. This model was chosen because of its availability, supported by the Water Resources Branch, Headquarters, and used successfully in the Atlantic region, Brimley, 1990. The model also uses the latest theory in estimating areal evapotranspiration by Morton, 1983.

Program BSTOR is menu driven and is basically user friendly.

2.2 Program BSTOR and Data Requirements

BSTOR is the main control program for the computation and analysis of the basin water balance and storage content. Central to the analysis is the independent estimates of the areal evapotranspiration on the basis of routine climatological observations provided by the Morton's model. The water balance equation for a drainage basin states that, the precipitation less runoff less evapotranspiration equals the change in basin storage, i.e.,

$$\Delta S = {}_1P_2 - {}_1R_2 - {}_1ET_2$$

where:

ΔS = change in storage ($\pm$), in millimetres (mm); in this study only ground water storage is considered significant;

${}_1P_2$ = uniform depth of precipitation over the basin, in millimetres, between time t_1 and t_2;

${}_1R_2$ = runoff depth over the basin, in millimetres, between time t_1 and t_2;

${}_1ET_2$ = evapotranspiration depth over the basin, in millimetres, between time t_1 and t_2.

The time period for computation (t_1 to t_2) is monthly. This is a limitation of the BSTOR program. The analysis is on the basis of water year (October 1 to September 30).

Precipitation and runoff are routinely observed or estimated and are readily available. The direct measurement of storage content on a monthly, seasonal or even an annual basis is too expensive and practically impossible on a basin scale. The alternative is a technique capable of a reliable independent estimate of areal evapotranspiration. Morton's model is considered to be such a technique.

The input data files required for the Morton model are: 1) average air temperature, 2) average dew point temperature and 3) sunshine duration. The other characteristics required for the Morton model are the latitude, the altitude and the average annual precipitation.

3.0 DATA AVAILABILITY

3.1 Station Data Used

The major weather makers (storms) in the Sheffield area track from the southeast or southwest. The North and South Mountains probably have an orographic affect on the storm systems; producing more precipitation on the hill sides than in the valley. The meteorologic stations chosen so as to best represent the study area are:

Greenwood "A"
Kentville "CDA"
Sheffield Mills "CDA"
Sharpe Brook "IHD" (discontinued)
Aylesford
Summerville
Waterville Cambridge
White Point

The hydrometric station that best represents streamflow conditions in the Sheffield Farm study area is Sharpe Brook at Lloyds (01DD004).

Figure 2 presents the location of the meteorologic stations and study basins.

3.2 Data Limitations

The success of a water balance depends a great deal on the accuracy of the discharge data, the accuracy of the drainage area, the accuracy and representativeness of the precipitation gauges and the ability to estimate the evapotranspiration.

The Sharpe Brook at Lloyds streamflow gauging station measures the runoff, on a continuous basis, from the north slope of the South Mountain in the Annapolis Valley. Sharpe Brook flows north and drains into the Cornwallis River which flows into Minas Basin. The basin has a typical bell shaped watershed that has a drainage area of 8.81 km^2 to the hydrometric gauge. The drainage area was delineated on 1:50,000 scale topographic maps by the Water Survey of Canada.

The physiography of the Sharpe Brook watershed consists of forest cover and is relatively untouched by man; the runoff information has natural flow records. Draining the South Mountain, the watershed has a relatively steep channel making the brook relatively flashy, i.e., the brook has a quick response rate. The watershed has an elevation difference of over 120 metres from the headwaters to the gauge.

SHEFFIELD FARM WATER BALANCE STUDY

LOCATION OF MET STATIONS AND STUDY BASINS

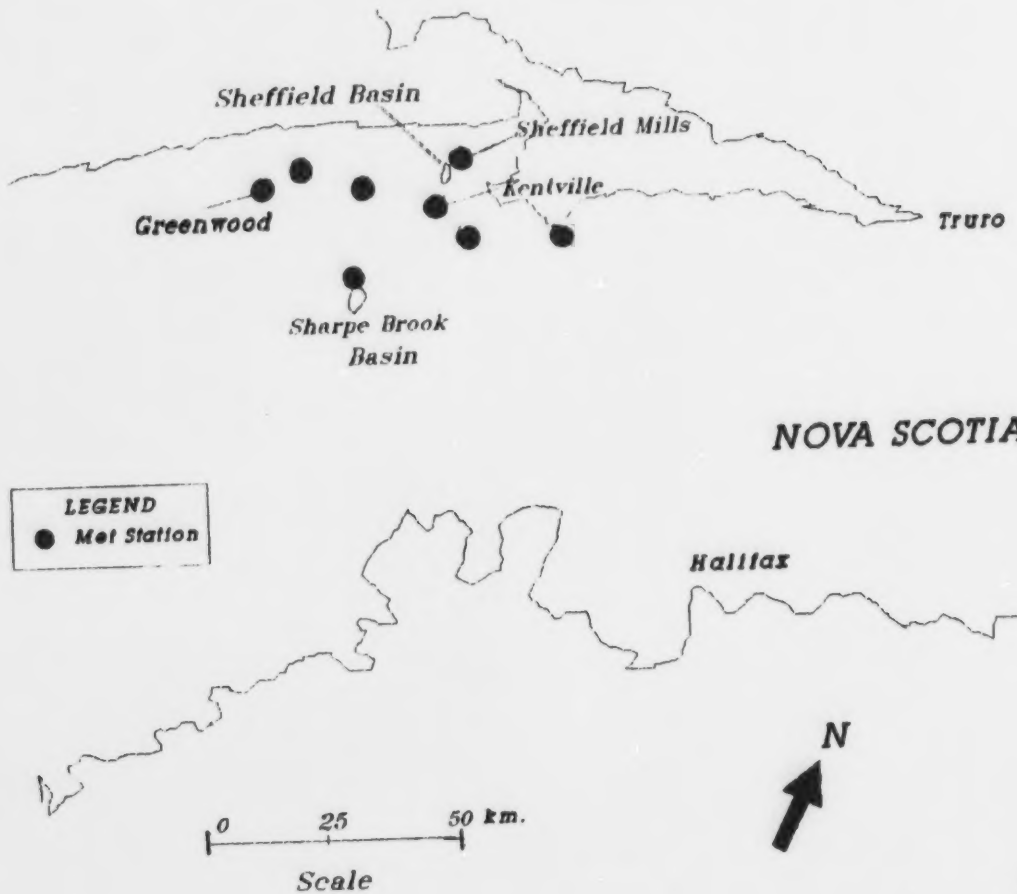


FIGURE 2

In contrast, the Sheffield study area (to the outlet of the artificial pond) drains approximately 2 km^2 of relatively flat agricultural land. The study basin originates in two channels just south of Highway 221. These channels are joined by a third tributary just above a swampy area upstream of the artificial pond. A controlled storage also exists on the main branch upstream of the artificial pond. These ponds have been created as a source for irrigation water and are drained in the fall and refilled each spring. The complications created by the undocumented regulation, irrigation withdrawals and unknown return flows from irrigation waters hampers the streamflow estimation based on naturally occurring data from nearby areas. Annual flows should be near natural however flows between May and October will be influenced by regulation. Once water has passed through the artificial pond, the stream crosses Highway 341 and joins the main branch of the Canard River.

The drainage area of Sharpe Brook is roughly four times larger than that of the study area. This parameter is important if used in the proration process. A drainage area difference of more than 25% can lead to gross errors in the water balance estimate. Also, the Sharpe Brook hydrometric station is approximately 17 kilometres away from the Sheffield study area, hence, the precipitation pattern may also be different.

The precipitation information (measurements) tend to underestimate (undercatch) the actual precipitation. Meteorologic stations are small samplings of a wide area and are rarely in the watershed being considered. For example, of the eight climate stations used, only one (Sharpe Brook "IHD") was located within a study basin. The Sharpe Brook climate station has been discontinued since December, 1978, and only used for comparison purposes in this study.

Sunshine data are only available at the Kentville "CDA" station. These data are required along with the latitude and longitude of the climate station to determine the radiant energy available for evaporation.

Air and dew point temperature are also necessary to estimate evapotranspiration. The dew point temperature data are only available at the Greenwood "A" climate station.

The evapotranspiration estimate needed to satisfy the water balance equation is determined from data at two nearby locations (Kentville and Greenwood stations). Air and dew point temperature should be measured at the same location; whereas, using sunshine data from a nearby station does not significantly alter the estimate of evapotranspiration, Brimley, 1990. These conditions are met in this study. The evapotranspiration estimate is assumed to represent both the Sheffield Farm and Sharpe Brook basins equally. Again, this is another estimate limitation due to data availability.

4.0 WATER BALANCE ANALYSIS

4.1 Introduction

Of the four variables in the water balance equation, the largest uncertainty lies in the basin storage. Some of the uncertainty can be minimized by the belief that the change in storage is cyclic and over the long-term is essentially zero, i.e., accumulated mean monthly storages approach zero. In Atlantic Canada, the streamflow runoff is directly controlled by and is the major share of the precipitation. Other than seasonal fluctuations, the annual storage changes are not expected to be deficient or excessive for more than a few years.

To reduce some of the uncertainty of the basin storage, the time series for model calibration should begin and end at or near the time when ground water, and hence basin storage is typically at its lowest value. The water year of October 1 to September 30 was chosen.

The parameter with the largest single value and the largest areal variability is the precipitation. The accuracy of this parameter depends upon the density of climate stations in or around the basin perimeter. This would also be true of the evapotranspiration estimate. Unfortunately, climate stations generally do not measure all the parameters to a degree of accuracy to best satisfy the balance equation.

The streamflow parameter is the most accurate element in the water balance equation and best represented by discharge in cubic metres per second. To transform streamflow from discharge to runoff in millimetres, as is needed for the balance, the drainage area of the basin must be known. The determination of drainage area of small watersheds, as found in this study, can also led to uncertainties.

The transposition of information from one basin to another further leads to uncertainties and doubts in parameter estimation in the water balance evaluation.

4.2 Preliminary Investigation

The period of record used to develop the water budget was based on runoff data available at the Sharpe Brook hydrometric station. The continuous period of unbroken record from October, 1967 to September, 1989 was used to calibrate the BSTOR model. The Morton areal evapotranspiration estimate was based on data from October, 1966 to September, 1989.

The BSTOR program uses the station files to create basin files which represent the average precipitation, evapotranspiration and runoff over the basin. The weighting or apportionment of the data is left to the user to determine. The weightings of the climate data can be determined by various methods, i.e., Thiessen polygon, isohyetal or the arithmetic mean of the individual station data.

The simplest method of determining average precipitation over a catchment area per year or per month is to calculate the arithmetic mean of all the precipitation gauges in the area. This technique gives adequate results if there is an even distribution of gauges and if the area is fairly flat (Ward, 1967); which is the case in this study.

The evapotranspiration estimate is based on air temperature, dew point temperature and sunshine information. Air and dew point temperature should be measured at the same location. The sunshine data can come from a nearby climate station. There is only one of these synoptic stations in the study basins. The average basin evapotranspiration estimate is based on the areal representation of data as measured at the Greenwood and Kentville climate stations. Total evapotranspiration is divided between areal evapotranspiration and lake evaporation. The Sharpe Brook representative basin is basically 100% woodland; the percentage of lake and/or wetland areas in the basin is insignificant and can be disregarded in the average basin evapotranspiration estimate.

Once the measured precipitation has been apportioned and files created for the basin, the water balance calculations can be performed. After various calculations of total precipitation, using the seven climate stations in the Sheffield Farm study area, it was found that there was no significant difference in the total precipitation estimate for the Sheffield Farm catchment using different combinations of the climate station. To determine the average total basin precipitation, the Greenwood, Kentville and Sheffield Mills climate stations were used. The Greenwood and Kentville stations were used since they served in the evapotranspiration estimate. The Sheffield Mills station was used due to its proximity to the Farm. The three stations were apportioned approximate equal weights.

The basin monthly precipitation estimate was also calculated using the computed rain and snowmelt estimate and the measured snow on the ground the last day of the month method. The same three stations as above were used with equal weights. There was basically no difference in the precipitation estimate as compared to the total precipitation method. The total precipitation method was used in this study due to the ease of obtaining the precipitation data.

4.3 Basin Storage Calculations

BSTOR calculates the change in basin storage on a monthly time interval using the water balance equation. Output listings of the monthly water balance components including the basin storage are produced. Mean monthly and mean monthly accumulated values of the water balance components are also produced in tabular and graphical formats.

By analyzing trends or changes in trend it is possible to assess if there are any irregularities in the basin storage data. This should be done in conjunction with analyses of the total precipitation, evapotranspiration and runoff time series data.

5.0 WATER BALANCE RESULTS

The water balance analysis was performed using data from the Sharpe Brook hydrometric (discharge/runoff) station and climate data from the Sheffield Farm study area. Figure 3 presents the schematic of the various stations and weights used to complete the water balance. The results showed a continuous storage loss representing about 10% of the precipitation value. The water balance model was re-run using a +10% and +20% precipitation adjustment factor. Figure 4 shows the accumulated basin storage using the different precipitation values. As can be seen from this figure at the +10% precipitation adjustment factor, the upward and downward trends are eliminated from the time series. When the precipitation data at climate stations near the Sheffield Farm were compared with the discontinued Sharpe Brook "IHD" precipitation, the precipitation at Sharpe Brook was 10% to 15% higher, i.e., the Farm climate stations were adjusted by +0.13 (+13%) to bring them in line with the Sharpe Brook values. This was based on the concurrent period of record, 1967 to 1978, for the average monthly and annual data series as shown in Tables 2 and 3. The Sharpe Brook climate station is about 100 metres higher in elevation than the Sheffield Farm climate stations, and more than likely influenced by orographic lift; therefore, more precipitation should fall over the Sharpe Brook drainage basin.

The calculated pan evaporations at Kentville and Sharpe Brook were also compared. Only a limited amount of comparable data were available, i.e, 1976 and 1977, for the June to September period. The evaporation values had a similar distribution but were different in magnitude. The Kentville values are about 25% higher than the Sharpe Brook pan evaporations. Various evapotranspiration adjustment factors were applied to the water balance calculation, but the best results (when the accumulated basin storage plot showed the least trend) were achieved when no adjustment factor was exercised.

The calculated pan evaporation at the Kentville climate station was compared with the Morton model estimate of lake evaporation for the Sheffield Farm study area. The difference between measured and calculated average monthly lake evaporation was about $\pm$10% error.

In Appendix A is presented the results of the water balance analysis for the Sharpe Brook basin. The total precipitation values were adjusted by +10%, as discussed in the first paragraph above; the Morton evapotranspiration computed values were not adjusted. The calibration period for the water balance model was October, 1967 to September, 1989. The period for computation of the Morton evapotranspiration model is October, 1966 to September, 1989. For completeness, the output tables and plots from the Morton evapotranspiration and evaporation models are presented in Appendix B.

FLOW CHART OF THE WATER BALANCE/STORAGE ON A MONTHLY BASIS

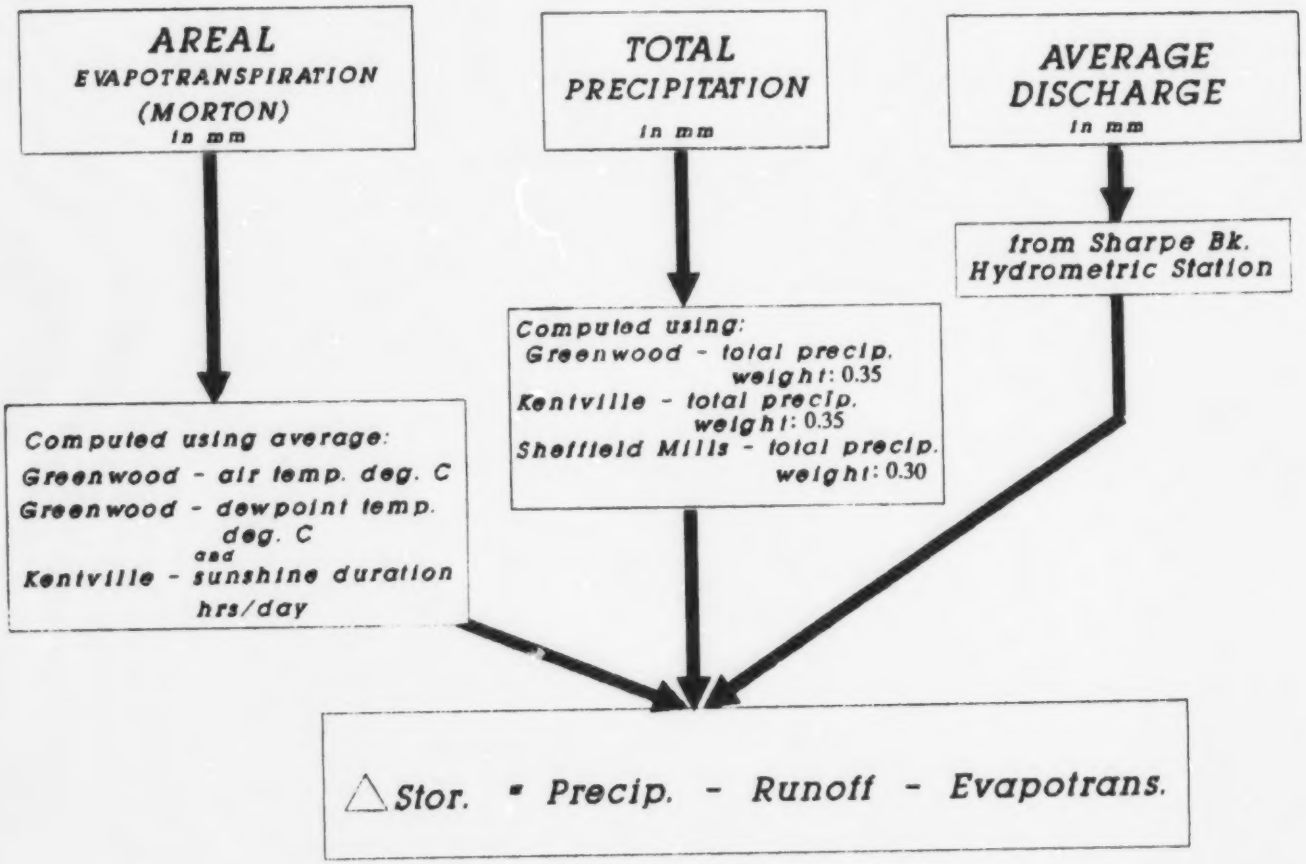
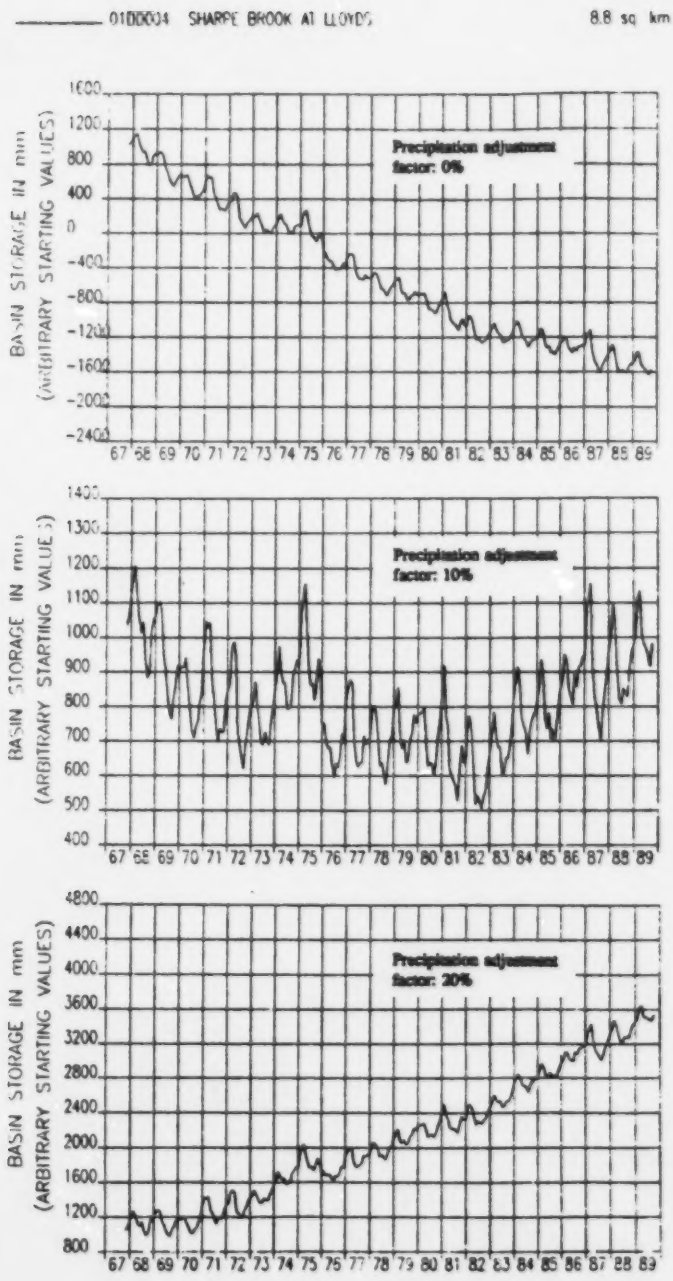


FIGURE 3


01000004 SHARPE BROOK AT LLOYDS
8.8 sq km
BASIN STORAGE IN mm
(ARBITRARY STARTING VALUES)
Precipitation adjustment factor: 0%
Precipitation adjustment factor: 10%
Precipitation adjustment factor: 20%
67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89

Accumulated Basin Storage Using Different Precipitation Adjustment Factors

FIGURE 4

12 YEAR AVERAGE (1967 - 1978)

MONTH	PRECIP (mm)	EVAPOTR. (mm)	RUNOFF (mm)
OCT	125.4	21.3	54.3
NOV	134.3	12.3	94.6
DEC	170.3	3.6	125.3
JAN	149.1	-0.1	85.5
FEB	108.5	4.7	71.0
MAR	118.0	24.1	100.7
APR	86.6	35.1	135.4
MAY	92.5	66.8	93.1
JUN	80.4	90.1	32.2
JUL	92.6	100.8	12.8
AUG	98.9	88.1	21.6
SEP	101.1	43.4	15.9
TOTAL	1357.6	490.1	842.3

PRECIP. ADJUSTMENT FACTOR = 0.00
EVAPOT. ADJUSTMENT FACTOR = 0.00

TABLE 1 Sharpe Brook "IHD" Climate Station with no Precipitation Adjustment Factor

12 YEAR AVERAGE (1967 - 1978)

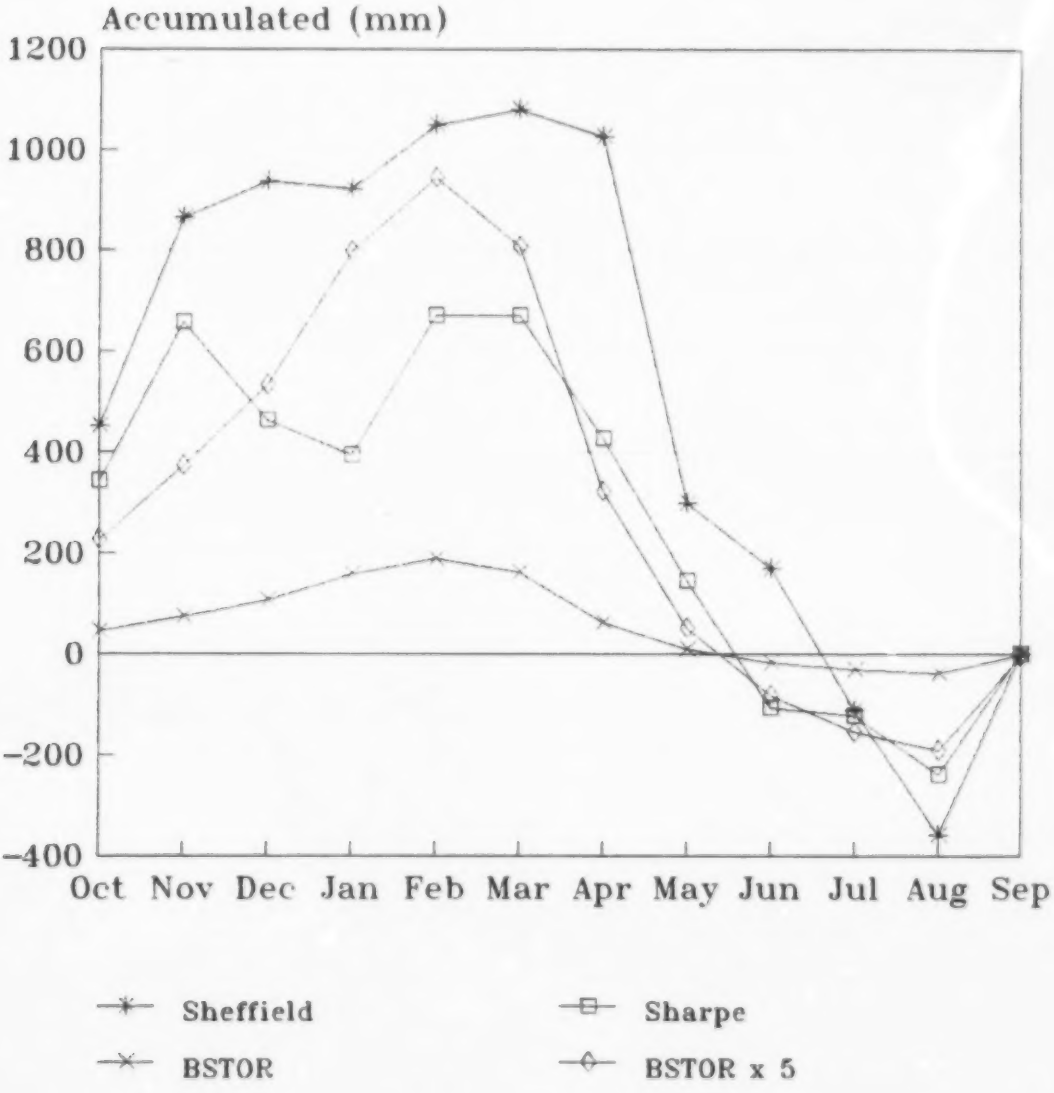
MONTH	PRECIP (mm)	EVAPOTR. (mm)	RUNOFF (mm)
OCT	123.7	21.3	54.3
NOV	135.2	12.3	94.6
DEC	159.9	3.6	125.3
JAN	134.9	-0.1	85.5
FEB	103.6	4.7	71.0
MAR	110.5	24.1	100.7
APR	86.4	35.1	135.4
MAY	93.9	66.8	93.1
JUN	86.9	90.1	32.2
JUL	98.2	100.8	12.8
AUG	99.4	88.1	21.6
SEP	102.7	43.4	15.9
TOTAL	1335.3	490.1	842.3

PRECIP. ADJUSTMENT FACTOR = 0.13
EVAPOT. ADJUSTMENT FACTOR = 0.00

TABLE 2 Sheffield Farm Study Area Climate Stations with a +13% Precipitation Adjustment Factor

A comparison of accumulated average monthly values of basin storage for the Sheffield Farm study area, the Sharpe Brook representative basin (after McIntosh, 1984) and the BSTOR model results are presented in Figure 5. The Sheffield and Sharpe line graphs are based on information from the Nova Scotia Department of the Environment observation wells. The BSTOR graph is based on the results from the water balance analysis. Although the monthly distribution of the plots are similar, the accumulated average monthly storages are quite different. The BSTOR plot differs by a factor of five (BSTOR x 5) when compared with the Sheffield and Sharpe plots. The long-term accumulated mean monthly storage approaches zero for all the line graphs in Figure 5, as expected. The reason(s) for the magnitude difference between calculated (BSTOR model) and measured change in storage is unknown. One reason could be that the plots are tabulated over different time periods. Also, the BSTOR storages are based on mean monthly data, whereas, the well data change in storage (for Sheffield and Sharpe Brook) are based on average maximum and minimum monthly ground water levels.

ACCUMULATED AVERAGE MONTHLY VALUES OF BASIN STORAGE – WATER YEAR



Period: Sheffield 1967–74
Sharpe 1971–81
BSTOR 1967–89

FIGURE 5

6.0 DISCUSSION

As mentioned previously, the water balance results are presented in Appendix A. The BSTOR model output listings are shown in Tables 1.A through 3.A and Figures 1.A through 4.A.

Table 1.A and the accompanying plot in Figure 1.A show the average distribution of the monthly and annual water balance input components. It should be noted that the runoff in March and April exceeds the precipitation. This is expected as wet conditions prevail during this time of year from snowmelt and the reduced infiltration capacity of the soil.

The change in storage can be determined by subtracting the evapotranspiration and runoff from the precipitation in the BSTOR model. This is presented in Table 2.A and Figure 2.A. These indicate that the assumption of the basin storage being zero over the long-term is reasonable. The average value of this uncertainty is shown in Table 2.A as -0.9 mm for September. This represents 0.2% of the estimated evapotranspiration; this represents a good result and within the standard reported by Morton.

Figure 3.A shows the basin storage over the period the model was calibrated, 1967 to 1989. For simplicity BSTOR assigns an arbitrary starting value of 1000 mm to basin storage in an attempt to keep the storage value a positive number. Figure 3.A indicates, except for short periods, i.e., 1968 through 1972 and 1985 through 1989, that basin storage does not appear to show any significant trend.

Table 3.A and Figure 4.A put all of the elements together to show the interaction between the various components. From this it is possible to note any isolated error in the precipitation/runoff relationship. No inconsistency was noted in the rainfall/runoff relationship.

Table 3.A also presents the monthly change in storage, at the Sharpe Brook representative basin, which is the primary objective of this study.

For completeness, a discussion of the Sheffield Farm hydrometric gauging station reconnaissance is presented in Appendix C and some observations on model verification are noted.

7.0 CONCLUSIONS

The conclusions in this report will address two main topics: 1) the results of the water balance for the Sharpe Brook basin, and 2) the applicability of transferring the Sharpe Brook results to the Sheffield Farm study basin to estimate basin storage.

In terms of applying the water balance model to the Sharpe Brook basin, a satisfactory balance can be achieved on a monthly basis. The following observations support this conclusion:

1) the drainage area of Sharpe Brook was based on the best delineations available;

2) the discharge data is assumed to be the most error free component in the water budget;

3) the precipitation data used, when adjusted by +10%, best represents the Sharpe Brook climate station data;

4) the areal evapotranspiration estimate is based on the best climate data available and is the least sensitive component of the water balance;

5) the rainfall/runoff relationship did not exhibit any noticeable inconsistencies;

6) the estimate of basin storage did not exhibit any noticeable irregularities like trend;

7) the assumption of basin storage approaching zero in the long-term is reasonable.

The degree of accuracy that can be expected from the water balance by transferring information from Sharpe Brook to the farm will depend upon how well the runoff compares at the two locations. Some positive and negative observations regarding the estimate of the water balance for the Sheffield Farm basin are as follows:

Positive Observations

1) measured precipitation data are available near the perimeter of the Sheffield Farm site;

2) climatic data needed for the Morton evapotranspiration estimate are available near the Sheffield Farm site;

3) direct measurements of the surface streamflow discharge from the Sheffield Farm site are not available; but a temporary hydrometric gauge has been installed some distance downstream;

4) the drainage area to the temporary gauge has been determined using the best mapping available, 1:10,000 scale topographic maps;

Negative Observations

5) the complications created by the undocumented regulation, irrigation withdrawals and unknown return flows from irrigation waters hampers the streamflow estimation based on naturally occurring data from nearby areas;

6) the physiography, geology and soils of the Sheffield Farm and the Sharpe Brook representative basin are quite different;

7) there is a size difference of more than 25% between the representative and farm drainage basins.

8.0 RECOMMENDATIONS

The recommendations address the verification of the Sharpe Brook water balance results to the transfer of information to the Sheffield Farm. It is recommended that:

1) the drainage area of the Sharpe Brook hydrometric gauging station be re-delineated on the best mapping available, this may in part explain the magnitude difference between calculated (BSTOR model) and measured change in storage as presented in Figure 5;

2) the temporary hydrometric station discharge data below the Farm be compared with the Sharpe Brook discharge data.

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APPENDIX A

OUTPUT TABLES AND PLOTS
FROM
THE BSTOR MODEL

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TABLE 2.A	Accumulated Values of Average Monthly Water Balance.
FIGURE 1.A	Average Monthly Water Balance.
FIGURE 2.A	Accumulated Values of Average Monthly Water Balance.
TABLE 3.A	Monthly Water Balance Components (six pages).
FIGURE 3.A	Accumulated Basin Storage.
FIGURE 4.A	Monthly Water Balance Components (three pages).

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
23 YEAR AVERAGE (1967 - 1989)

MONTH	PRECIP (mm)	EVAPOTR. (mm)	RUNOFF (mm)
OCT	109.3	20.3	43.4
NOV	124.9	12.9	83.0
DEC	135.6	3.1	100.2
JAN	127.5	-0.5	75.3
FEB	99.4	4.4	65.6
MAR	108.4	25.0	110.8
APR	88.7	36.6	149.3
MAY	95.1	65.1	84.1
JUN	96.8	87.9	35.8
JUL	101.6	100.4	15.4
AUG	95.5	84.1	18.9
SEP	96.1	43.9	15.1
TOTAL	1279.0	483.0	796.9

PRECIP. ADJUSTMENT FACTOR = 0.10
EVAPOT. ADJUSTMENT FACTOR = 0.00

TABLE 1.A Average Monthly Water Balance

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
23 YEAR AVERAGE (1967 - 1989)
ACCUMULATED VALUES OF WATER BALANCE COMPONENTS(mm)

TO END OF	P	P -ET	P -ET-R
OCT	109.3	89.0	45.6
NOV	234.2	201.0	74.6
DEC	369.8	333.6	106.9
JAN	497.3	461.5	159.6
FEB	596.7	556.6	189.0
MAR	705.1	640.0	161.7
APR	793.8	692.1	64.5
MAY	889.0	722.2	10.5
JUN	985.8	731.2	-16.4
JUL	1087.4	732.3	-30.6
AUG	1182.9	743.8	-38.0
SEP	1279.0	796.0	-0.9

AVE. PRECIP.	AVE. EVAPOTR.	AVE. RUNOFF
1279.0	483.0	796.9

PRECIP. ADJUSTMENT FACTOR = 0.10
EVAPOT. ADJUSTMENT FACTOR = 0.00

TABLE 2.A Accumulated Values of Average Monthly Water Balance

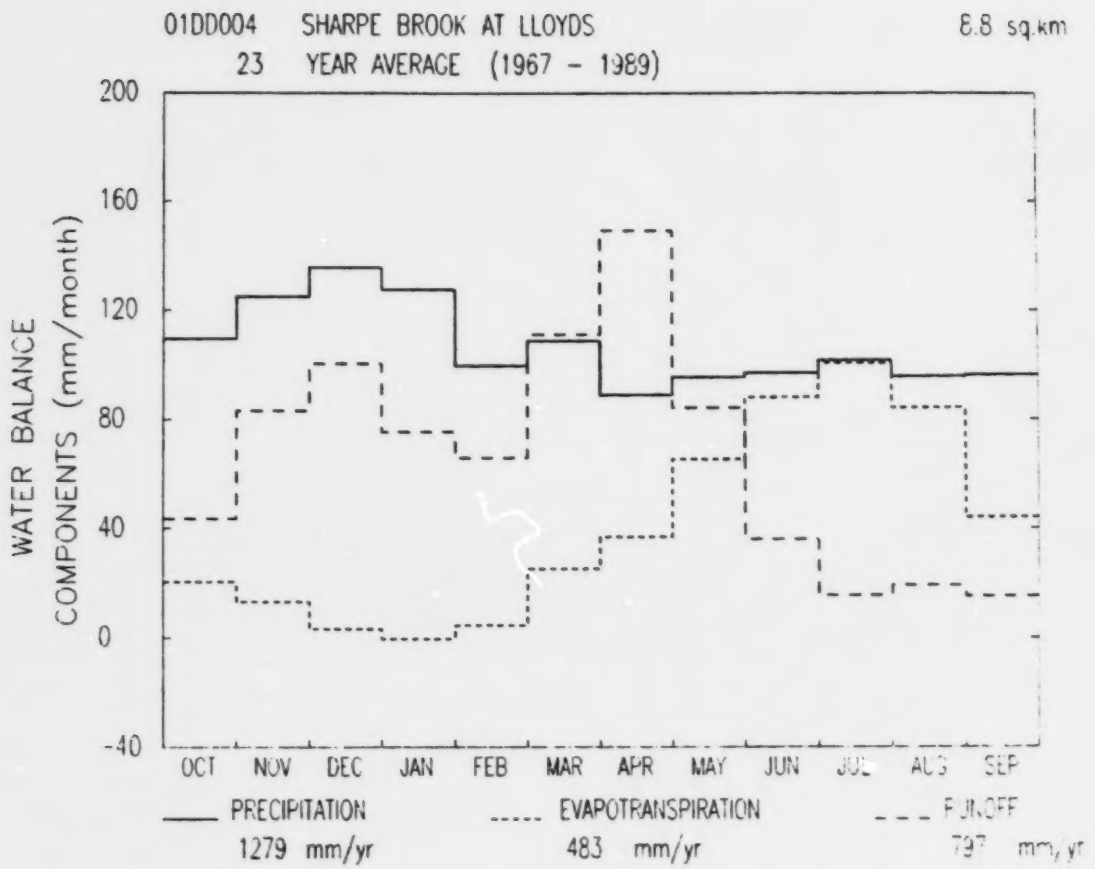

FIGURE 1.A Average Monthly Water Balance

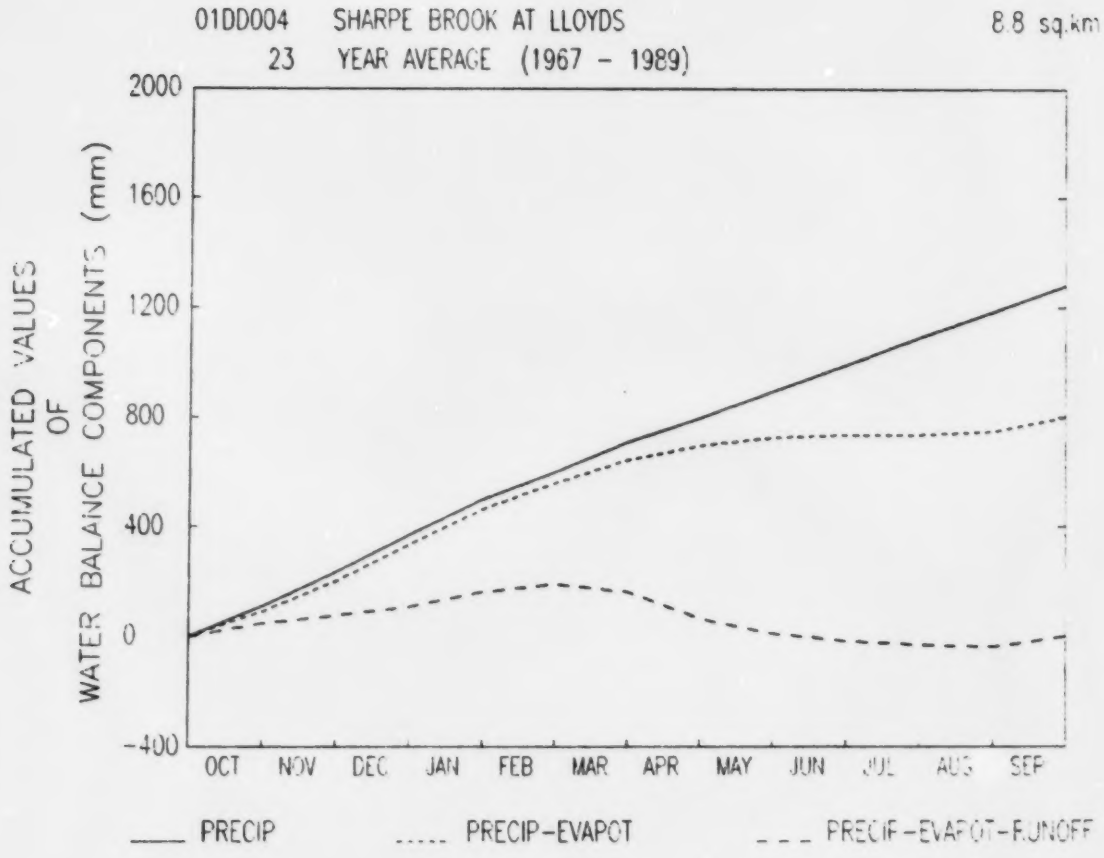

FIGURE 2.A Accumulated Values of Average Monthly Water Balance

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
	STARTING VALUE FOR STORAGE = 1000 mm.				
	PRECIP. ADJUSTMENT FACTOR = 0.10				
	EVAPOT. ADJUSTMENT FACTOR = 0.00				
1967	10	108.4	28.6	42.6	1037.3
1967	11	125.5	14.3	85.3	1063.2
1967	12	222.9	0.2	154.7	1131.1
1968	1	100.2	-2.5	56.5	1177.3
1968	2	74.2	1.4	41.2	1208.8
1968	3	113.9	23.0	190.0	1109.8
1968	4	58.4	42.9	72.7	1052.6
1968	5	66.5	71.7	34.4	1013.1
1968	6	164.3	75.1	56.2	1046.1
1968	7	25.0	118.9	11.2	940.9
1968	8	43.7	101.2	0.9	882.5
1968	9	59.4	42.9	0.6	898.3
1968	10	175.4	20.9	37.7	1015.1
1968	11	195.1	10.3	144.2	1055.7
1968	12	131.8	4.3	122.2	1061.0
1969	1	122.0	-0.7	84.8	1098.9
1969	2	98.1	4.8	87.9	1104.4
1969	3	79.7	23.7	80.3	1080.1
1969	4	122.5	49.6	200.9	952.0
1969	5	98.3	81.4	57.2	911.8
1969	6	47.9	109.5	13.5	836.7
1969	7	53.5	101.2	2.4	786.5
1969	8	71.2	92.4	0.9	764.4
1969	9	99.7	40.8	1.2	822.1
1969	10	69.6	21.2	4.6	866.0
1969	11	97.4	13.0	30.3	920.1
1969	12	127.5	5.6	133.5	908.6
1970	1	34.7	-0.1	30.1	913.3
1970	2	75.7	6.1	70.0	912.9
1970	3	82.0	22.8	30.1	942.0
1970	4	70.4	37.9	115.9	858.6
1970	5	89.4	74.5	78.4	795.1
1970	6	64.8	104.3	23.8	731.7
1970	7	105.5	118.5	10.3	708.4
1970	8	129.9	85.1	15.5	737.6
1970	9	81.2	51.2	10.3	757.3
1970	10	144.9	23.4	71.1	807.6
1970	11	144.3	11.8	100.0	840.2
1970	12	179.8	-3.5	45.6	977.9
1971	1	117.3	-2.0	50.5	1046.7
1971	2	106.9	3.4	125.2	1024.9
1971	3	126.8	24.5	81.8	1045.4
1971	4	88.8	34.3	234.8	865.2
1971	5	173.0	62.3	144.4	831.5
1971	6	34.7	98.6	24.7	742.8
1971	7	69.7	112.7	2.4	697.4
1971	8	262.4	102.5	120.7	736.5
1971	9	58.8	56.4	13.8	725.1

TABLE 3.A Monthly Water Balance Components

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
	STARTING VALUE FOR STORAGE = 1000 mm.				
	PRECIP. ADJUSTMENT FACTOR = 0.10				
	EVAPOT. ADJUSTMENT FACTOR = 0.00				
1971	10	33.1	22.4	9.1	726.7
1971	11	155.4	12.4	51.5	818.2
1971	12	111.8	2.3	81.5	846.2
1972	1	127.5	0.1	104.9	868.7
1972	2	152.0	4.6	44.7	971.5
1972	3	174.1	18.6	139.2	987.8
1972	4	88.7	33.4	90.6	952.4
1972	5	111.8	87.5	250.2	726.4
1972	6	94.9	91.4	35.9	694.0
1972	7	73.6	94.3	15.8	657.6
1972	8	72.4	96.4	14.0	619.6
1972	9	104.8	35.4	7.1	681.9
1972	10	132.9	22.7	61.7	730.3
1972	11	222.3	13.7	167.1	771.7
1972	12	131.8	6.1	82.4	815.1
1973	1	68.4	4.0	69.6	809.9
1973	2	127.7	4.7	61.2	871.6
1973	3	90.8	22.1	130.7	809.7
1973	4	79.0	31.3	106.2	751.2
1973	5	69.5	51.4	73.6	695.6
1973	6	135.4	85.7	57.4	687.9
1973	7	176.1	98.1	38.9	727.0
1973	8	88.2	81.0	31.3	702.9
1973	9	30.0	42.5	2.4	688.1
1973	10	92.5	18.1	4.0	758.5
1973	11	85.9	13.3	33.5	797.6
1973	12	170.6	10.4	105.8	851.9
1974	1	118.7	5.9	60.2	904.5
1974	2	143.2	2.4	71.1	974.2
1974	3	77.7	24.2	121.9	905.7
1974	4	96.8	28.5	107.4	866.7
1974	5	99.8	42.9	54.1	869.4
1974	6	37.5	81.3	30.9	794.7
1974	7	87.3	81.8	7.0	793.2
1974	8	104.5	82.6	5.5	809.6
1974	9	161.8	53.4	28.8	889.2
1974	10	144.6	19.4	101.8	912.5
1974	11	135.2	9.9	102.4	935.5
1974	12	92.9	4.9	101.2	922.2
1975	1	198.2	-0.3	59.6	1061.1
1975	2	80.7	5.0	25.0	1111.9
1975	3	161.4	28.8	89.1	1155.4
1975	4	64.6	27.0	163.9	1029.1
1975	5	59.4	51.4	123.1	913.9
1975	6	56.7	82.9	26.8	860.9
1975	7	94.8	86.3	3.3	866.1
1975	8	23.2	68.0	1.2	820.1
1975	9	115.3	39.1	15.9	880.4

TABLE 3.A (continued)

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
	STARTING VALUE FOR STORAGE = 1000 mm.				
	PRECIP. ADJUSTMENT FACTOR = 0.10				
	EVAPOT. ADJUSTMENT FACTOR = 0.00				
1975	10	123.9	18.5	46.2	939.6
1975	11	115.1	9.9	167.1	877.7
1975	12	162.7	3.2	304.0	733.2
1976	1	173.6	-2.0	154.4	754.5
1976	2	136.9	15.6	180.9	694.9
1976	3	95.0	18.5	91.8	679.6
1976	4	96.5	29.3	63.8	683.0
1976	5	100.4	65.3	80.9	637.3
1976	6	51.9	86.2	9.1	593.8
1976	7	164.4	100.3	21.6	636.3
1976	8	75.6	84.4	5.5	622.0
1976	9	86.8	36.7	15.3	656.8
1976	10	159.3	17.6	74.8	723.8
1976	11	67.8	14.9	77.7	699.0
1976	12	239.1	0.9	121.3	816.0
1977	1	126.0	-1.8	88.5	855.3
1977	2	73.2	1.7	48.1	878.7
1977	3	119.1	25.0	103.7	869.2
1977	4	74.7	40.9	202.1	700.9
1977	5	111.7	74.1	95.5	643.1
1977	6	137.1	88.3	66.5	625.4
1977	7	141.2	105.9	24.0	636.8
1977	8	125.5	88.1	36.8	637.4
1977	9	194.4	40.6	75.3	715.8
1977	10	139.8	21.5	143.5	690.6
1977	11	103.7	11.6	81.5	701.3
1977	12	141.2	5.3	125.9	711.3
1978	1	258.2	-1.9	181.5	789.9
1978	2	41.0	1.5	25.5	803.9
1978	3	62.4	34.2	48.9	783.1
1978	4	84.8	30.6	130.6	706.6
1978	5	26.2	71.9	32.2	628.7
1978	6	105.8	87.9	9.4	637.2
1978	7	59.9	90.9	3.3	602.8
1978	8	67.5	87.8	5.8	576.8
1978	9	107.7	38.0	4.7	641.9
1978	10	88.1	19.9	11.6	698.5
1978	11	42.3	10.7	10.3	719.9
1978	12	112.1	-0.3	33.7	798.5
1979	1	237.4	1.6	220.7	813.5
1979	2	129.2	1.7	84.3	856.8
1979	3	118.4	24.7	240.5	710.0
1979	4	100.7	32.5	100.6	677.6
1979	5	162.9	50.2	85.1	705.2
1979	6	75.3	89.7	53.5	637.2
1979	7	116.5	105.5	9.4	638.8
1979	8	164.7	69.2	29.2	705.1
1979	9	87.5	53.3	18.8	720.5

TABLE 3.A (continued)

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
	STARTING VALUE FOR STORAGE = 1000 mm.				
	PRECIP. ADJUSTMENT FACTOR = 0.10				
	EVAPOT. ADJUSTMENT FACTOR = 0.00				
1979	10	144.5	21.5	66.0	777.5
1979	11	169.5	16.6	178.3	752.0
1979	12	143.4	2.6	115.8	777.0
1980	1	54.0	0.7	51.4	779.0
1980	2	23.8	4.0	12.8	785.9
1980	3	115.2	25.5	76.6	798.9
1980	4	73.2	38.0	134.7	699.3
1980	5	28.8	56.4	44.4	627.3
1980	6	126.3	88.1	29.7	635.8
1980	7	125.5	84.8	41.7	634.9
1980	8	52.5	79.6	7.6	600.1
1980	9	81.3	38.3	4.4	638.7
1980	10	110.8	16.1	21.0	712.4
1980	11	149.6	14.1	80.6	767.3
1980	12	166.3	-3.0	113.4	823.2
1981	1	173.8	-4.5	83.3	918.2
1981	2	50.5	13.0	181.0	774.8
1981	3	107.4	21.6	114.3	746.2
1981	4	83.1	26.4	185.9	617.0
1981	5	110.7	58.8	66.9	602.0
1981	6	112.6	94.4	36.2	584.1
1981	7	99.8	103.1	7.0	573.7
1981	8	47.7	87.7	5.5	528.2
1981	9	129.4	33.9	11.5	612.2
1981	10	171.1	19.7	75.7	687.9
1981	11	154.8	15.4	190.1	637.3
1981	12	176.8	1.8	176.0	636.3
1982	1	172.8	-3.0	55.0	757.1
1982	2	88.7	2.2	69.2	774.4
1982	3	76.2	27.1	100.0	723.5
1982	4	136.7	41.9	196.5	621.8
1982	5	50.2	79.7	74.8	517.5
1982	6	111.1	69.6	16.2	542.8
1982	7	100.1	110.5	7.6	524.8
1982	8	54.6	70.7	4.3	504.5
1982	9	90.5	48.6	3.5	542.9
1982	10	33.5	19.7	2.7	553.9
1982	11	106.5	16.4	11.5	632.6
1982	12	105.7	5.7	68.1	664.5
1983	1	98.7	1.8	45.9	715.4
1983	2	97.1	0.5	26.4	785.7
1983	3	118.1	26.1	156.6	721.1
1983	4	93.9	38.0	96.8	680.1
1983	5	160.6	63.3	92.7	684.8
1983	6	48.1	94.6	36.2	602.1
1983	7	97.6	90.1	1.8	607.8
1983	8	125.9	78.3	2.4	652.9
1983	9	42.1	44.2	3.5	647.3

TABLE 3.A (continued)

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

STARTING VALUE FOR STORAGE = 1000 mm.
PRECIP. ADJUSTMENT FACTOR = 0.10
EVAPOT. ADJUSTMENT FACTOR = 0.00

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
1983	10	53.0	18.1	1.8	680.4
1983	11	100.6	15.6	13.2	752.1
1983	12	129.4	5.1	46.2	830.1
1984	1	118.6	-1.6	52.0	898.3
1984	2	116.8	14.4	85.9	914.8
1984	3	129.4	29.4	166.0	848.8
1984	4	96.1	35.0	142.4	767.4
1984	5	96.2	61.2	61.4	741.0
1984	6	102.7	89.0	24.7	730.0
1984	7	61.6	121.8	8.2	661.6
1984	8	174.4	87.3	28.0	720.8
1984	9	113.5	45.8	34.1	754.3
1984	10	51.2	17.3	13.1	775.2
1984	11	33.8	10.8	12.4	785.8
1984	12	93.9	8.0	56.2	815.4
1985	1	72.1	-1.6	15.8	873.2
1985	2	105.8	2.6	39.8	936.6
1985	3	100.7	26.8	132.6	878.0
1985	4	63.8	40.5	137.4	763.9
1985	5	156.1	60.9	122.2	736.9
1985	6	224.1	78.1	99.4	783.4
1985	7	60.4	112.5	25.2	706.1
1985	8	135.5	85.0	21.0	735.5
1985	9	20.4	48.7	9.7	697.4
1985	10	69.0	16.8	5.2	744.5
1985	11	110.4	14.7	29.7	810.5
1985	12	62.8	0.5	20.1	852.7
1986	1	136.4	1.2	104.6	883.3
1986	2	93.5	4.9	20.3	951.6
1986	3	162.5	29.7	151.4	933.0
1986	4	106.6	36.6	150.9	852.0
1986	5	113.9	65.6	69.3	831.0
1986	6	96.1	82.1	38.2	806.7
1986	7	198.3	79.7	31.0	894.2
1986	8	89.8	73.4	54.4	856.2
1986	9	125.9	44.2	25.0	912.9
1986	10	62.8	20.7	37.7	917.3
1986	11	96.1	11.1	60.0	942.3
1986	12	63.0	5.1	53.2	947.0
1987	1	152.9	-2.1	23.7	1078.3
1987	2	51.2	0.2	11.5	1117.8
1987	3	106.0	29.8	36.8	1157.2
1987	4	71.7	46.0	263.6	919.3
1987	5	65.4	63.2	96.4	825.1
1987	6	105.0	91.0	42.4	796.8
1987	7	50.3	100.5	5.8	740.8
1987	8	43.0	80.8	1.2	701.7
1987	9	155.7	43.0	20.0	794.5

TABLE 3.A (continued)

01DD004 SHARPE BROOK AT LLOYDS
DRAINAGE AREA = 8.81 sq.km.
MONTHLY WATER BALANCE COMPONENTS WITH BASIN STORAGE(mm)
from OCT 1967 to SEP 1989

YEAR	MONTH	PRECIP	EVAPOTR	RUNOFF	STORAGE
	STARTING VALUE FOR STORAGE = 1000 mm.				
	PRECIP. ADJUSTMENT FACTOR = 0.10				
	EVAPOT. ADJUSTMENT FACTOR = 0.00				
1987	10	130.2	20.7	59.0	845.0
1987	11	153.6	10.8	76.5	911.3
1987	12	148.3	0.3	97.6	961.6
1988	1	77.0	-1.6	25.8	1014.4
1988	2	177.1	1.4	92.1	1097.9
1988	3	46.3	21.9	78.7	1043.6
1988	4	133.8	38.5	240.7	898.2
1988	5	58.1	72.6	62.9	820.7
1988	6	89.1	78.3	24.4	807.0
1988	7	182.3	89.9	45.6	853.8
1988	8	85.0	82.5	17.6	838.7
1988	9	40.0	42.1	7.9	828.7
1988	10	166.3	21.0	64.1	909.8
1988	11	182.3	11.9	123.9	956.4
1988	12	69.0	2.0	46.5	976.9
1989	1	66.2	0.4	37.1	1005.7
1989	2	144.5	0.2	39.5	1110.4
1989	3	122.3	22.2	75.7	1134.8
1989	4	66.8	45.2	145.0	1011.3
1989	5	84.2	65.7	49.6	980.2
1989	6	109.0	86.6	33.2	969.3
1989	7	91.5	101.4	15.2	944.2
1989	8	64.4	85.8	6.4	916.5
1989	9	128.0	45.7	17.9	980.8

TABLE 3.A (continued)

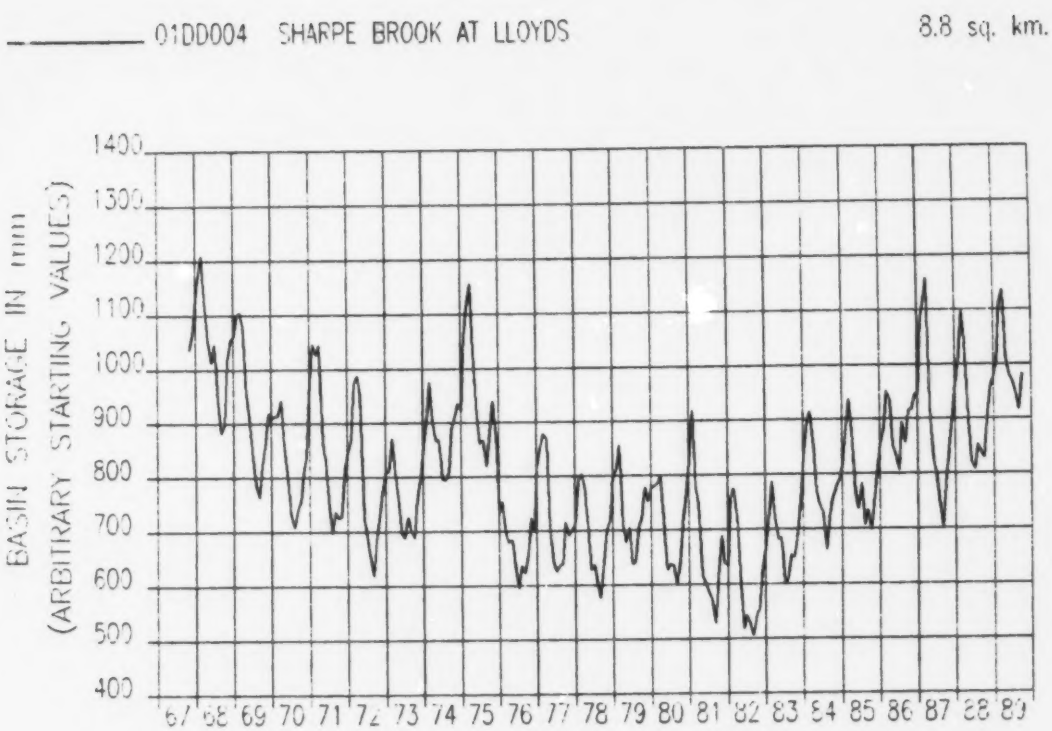

FIGURE 3.A Accumulated Basin Storage

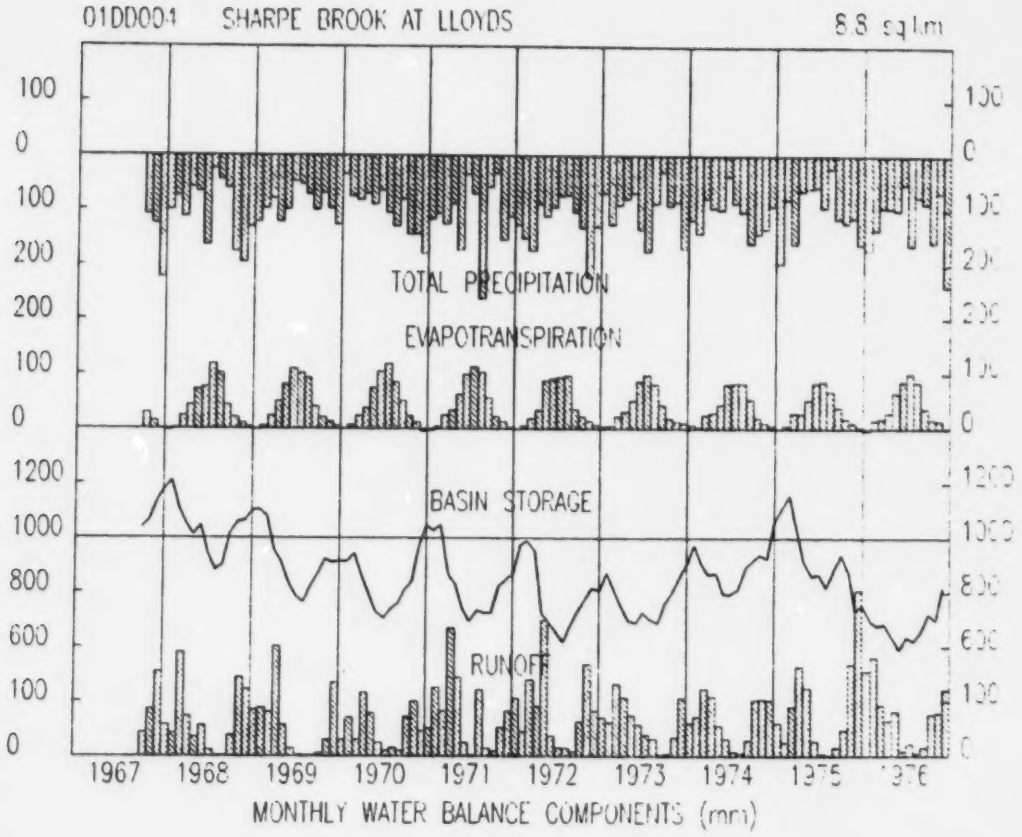

FIGURE 4.A Monthly Water Balance Components

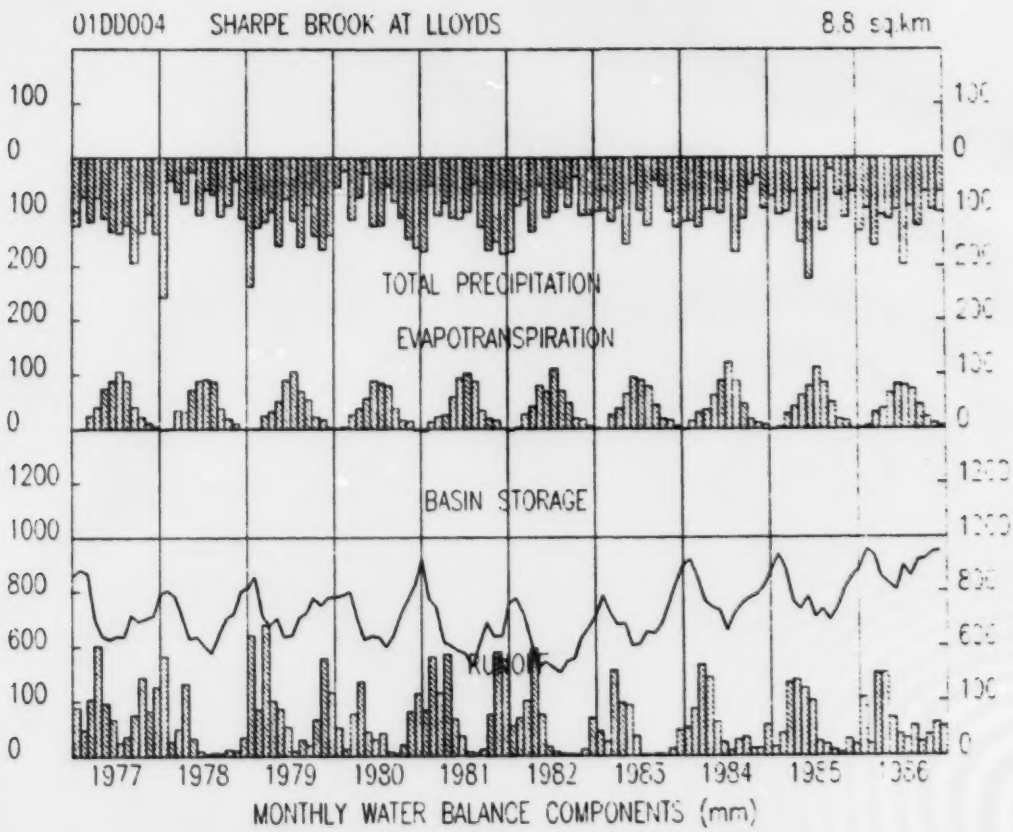

FIGURE 4.A (continued)

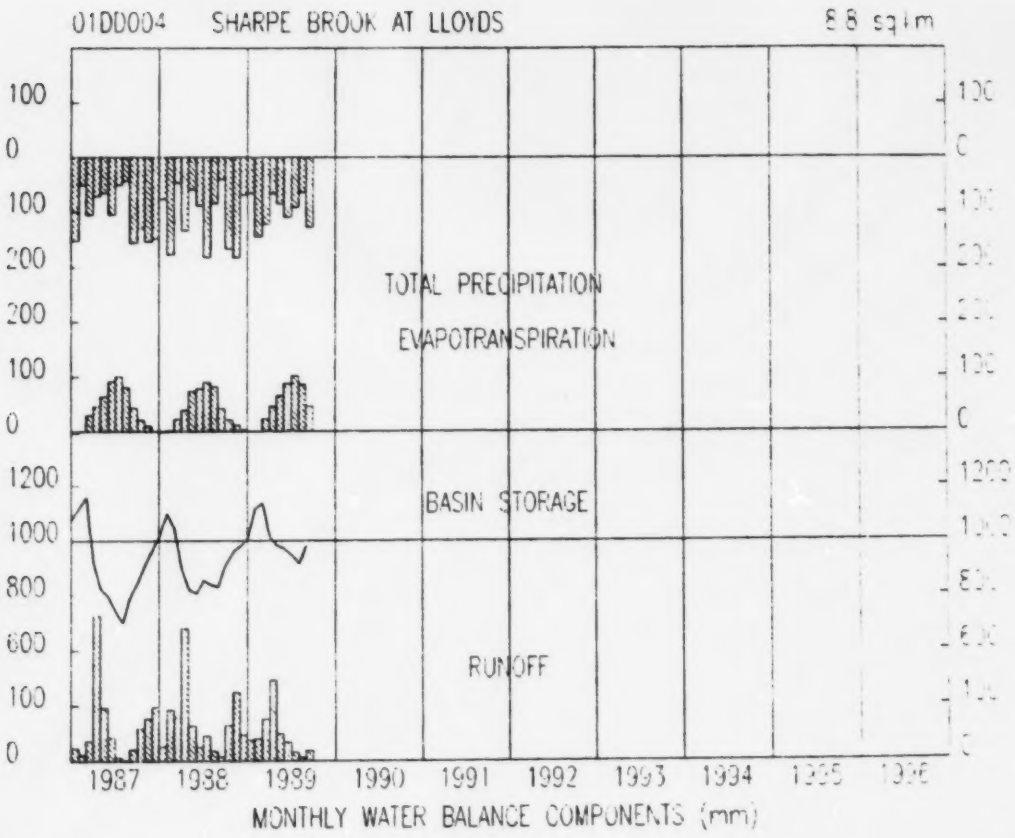

FIGURE 4.A (continued)

APPENDIX B

OUTPUT TABLES AND PLOTS
FROM
THE MORTON EVAPOTRANSPIRATION MODEL

Contents

TABLE 1.B	Average Monthly Potential and Areal Evapotranspiration.
FIGURE 1.B	Average Monthly Potential and Areal Evapotranspiration.
TABLE 2.B	Monthly Potential and Areal Evapotranspiration (six pages).

greenwood a
MONTHLY TOTALS AVERAGED OVER 24 YEAR(s) (1966-1989)

MONTH	NET RAD.	EVAPOTRANSPIRATION POTENTIAL	AREAL
JAN	-22.0	-0.5	-0.5
FEB	-9.0	4.1	4.1
MAR	33.4	37.6	24.2
APR	69.2	72.4	36.7
MAY	108.8	115.2	64.4
JUN	128.2	139.3	87.3
JUL	138.3	158.9	101.0
AUG	116.8	137.6	84.5
SEP	66.1	85.8	44.3
OCT	20.3	41.8	20.2
NOV	-4.4	13.6	12.9
DEC	-18.9	3.1	3.1
AVERAGE	626.8	808.7	482.0

TABLE 1.B Average Monthly Potential and Areal Evapotranspiration

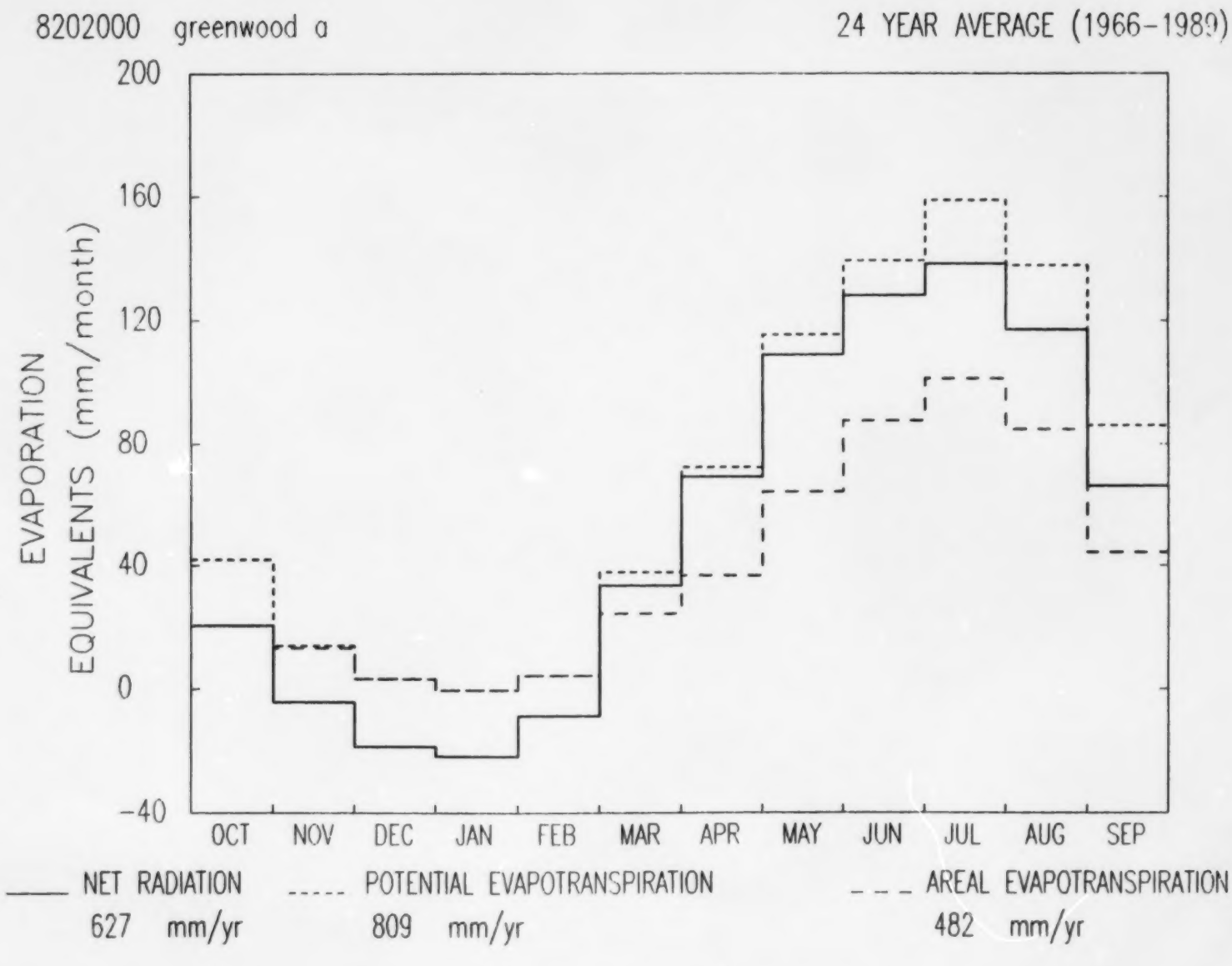

FIGURE 1.8 Average Monthly Potential and Areal Evapotranspiration

8202000 greenwood a 8202000 - 1
44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m
AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1966	OCT	4.6	8.6	5.07	22.8	46.6	19.3
1966	NOV	3.4	5.9	2.12	-2.6	12.8	12.8
1966	DEC	-2.6	-0.4	1.99	-16.3	2.9	2.9
1967	JAN	-5.7	-3.9	2.40	-22.4	-2.1	-2.1
1967	FEB	-9.8	-8.2	3.71	-13.5	-1.7	-1.7
1967	MAR	-6.8	-5.1	4.03	3.3	5.9	5.9
1967	APR	-3.2	1.5	5.17	72.1	63.7	38.9
1967	MAY	2.5	7.5	4.91	86.7	90.2	48.6
1967	JUN	10.2	16.6	6.99	124.7	152.2	75.4
1967	JUL	16.9	20.9	6.91	135.5	146.8	113.3
1967	AUG	15.6	19.7	7.11	117.9	133.6	94.1
1967	SEP	10.9	14.0	5.89	66.7	75.8	53.7
1967	OCT	6.4	8.9	3.96	29.0	42.3	28.6
1967	NOV	1.0	3.4	3.11	2.8	14.3	14.3
1967	DEC	-4.7	-2.5	2.10	-21.1	0.2	0.2
1968	JAN	-10.1	-8.0	3.25	-23.5	-2.5	-2.5
1968	FEB	-11.8	-8.5	4.53	-17.4	1.4	1.4
1968	MAR	-3.3	0.4	3.44	33.0	41.0	23.0
1968	APR	0.5	5.8	6.03	82.1	83.9	42.9
1968	MAY	4.1	9.1	6.76	116.1	109.3	71.7
1968	JUN	9.7	14.2	5.77	107.7	114.4	75.1
1968	JUL	13.9	19.8	9.68	164.1	185.2	118.9
1968	AUG	12.4	16.6	8.71	131.8	134.0	101.2
1968	SEP	11.4	15.3	5.34	61.4	84.9	42.9
1968	OCT	7.6	11.1	4.98	23.9	49.2	20.9
1968	NOV	-0.6	1.9	2.23	-3.9	10.3	10.3
1968	DEC	-4.4	-1.6	1.73	-16.2	4.3	4.3
1969	JAN	-6.1	-4.0	2.44	-21.0	-0.7	-0.7
1969	FEB	-5.5	-2.7	1.42	-9.6	4.8	4.8
1969	MAR	-5.2	-1.2	4.40	32.7	38.4	23.7
1969	APR	0.2	4.2	5.78	80.0	68.7	49.6
1969	MAY	5.0	9.6	7.24	123.7	111.1	81.4
1969	JUN	11.8	16.4	8.27	145.0	143.8	109.5
1969	JUL	12.5	18.0	8.15	143.6	161.1	101.2
1969	AUG	14.4	18.7	7.47	119.8	134.4	92.4
1969	SEP	10.8	14.6	5.06	58.1	80.3	40.8
1969	OCT	4.4	7.7	4.63	20.3	39.4	21.2
1969	NOV	2.8	5.4	2.19	-2.5	13.0	13.0
1969	DEC	-1.9	0.6	1.37	-18.6	5.6	5.6
1970	JAN	-12.3	-9.0	3.30	-25.6	-0.1	-0.1
1970	FEB	-7.6	-4.5	3.57	-4.1	6.1	6.1
1970	MAR	-5.0	-1.0	4.28	31.4	38.4	22.8
1970	APR	-1.4	3.9	5.49	75.4	75.6	37.9
1970	MAY	7.0	11.6	6.43	112.1	111.6	74.5
1970	JUN	11.8	16.2	7.70	137.5	136.5	104.3
1970	JUL	14.9	19.6	8.44	151.0	161.5	118.5
1970	AUG	14.8	19.3	6.85	113.1	134.7	85.1
1970	SEP	10.3	13.2	4.44	62.1	69.5	51.2

TABLE 2.B Monthly Potential and Areal Evapotranspiration

8202000 greenwood a 8202000 - 2

44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m

AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1970	OCT	7.2	9.9	4.70	22.5	41.6	23.4
1970	NOV	1.5	4.1	3.53	-4.2	11.8	11.8
1970	DEC	-8.2	-6.3	1.82	-26.5	-3.5	-3.5
1971	JAN	-10.3	-8.0	2.41	-23.8	-2.0	-2.0
1971	FEB	-7.5	-5.0	3.64	-7.1	3.4	3.4
1971	MAR	-3.9	-0.1	4.52	33.5	40.4	24.5
1971	APR	0.7	5.2	4.48	61.3	67.1	34.3
1971	MAY	7.3	11.7	5.26	94.5	100.7	62.3
1971	JUN	9.3	15.4	8.83	149.8	158.8	98.6
1971	JUL	14.3	19.2	8.26	147.7	160.6	112.7
1971	AUG	14.6	18.3	7.84	124.9	128.7	102.5
1971	SEP	11.8	15.0	6.17	70.3	81.0	56.4
1971	OCT	6.1	9.2	5.15	24.6	45.0	22.4
1971	NOV	0.1	2.7	2.69	-0.2	12.4	12.4
1971	DEC	-6.6	-3.7	1.94	-19.8	2.3	2.3
1972	JAN	-7.6	-5.1	2.23	-21.0	0.1	0.1
1972	FEB	-10.9	-7.2	4.81	-10.0	4.6	4.6
1972	MAR	-5.4	-2.8	2.91	13.6	18.6	18.6
1972	APR	-2.2	2.0	4.05	57.7	56.0	33.4
1972	MAY	5.7	11.0	8.18	136.6	129.1	87.5
1972	JUN	12.2	16.5	6.50	121.3	126.8	91.4
1972	JUL	13.8	18.9	7.01	130.3	151.4	94.3
1972	AUG	12.6	17.5	8.82	132.6	145.7	96.4
1972	SEP	9.4	13.9	5.38	59.4	87.3	35.4
1972	OCT	3.8	6.8	3.60	23.8	40.3	22.7
1972	NOV	-1.5	1.8	2.48	-2.7	13.8	13.8
1972	DEC	-7.6	-3.7	1.58	-16.2	6.1	6.1
1973	JAN	-7.9	-4.5	3.03	-17.2	4.0	4.0
1973	FEB	-8.8	-5.8	3.28	-5.3	4.7	4.7
1973	MAR	-4.1	1.0	5.43	47.4	57.2	22.1
1973	APR	-0.5	5.0	4.92	67.0	76.6	31.3
1973	MAY	5.7	10.1	4.11	82.0	89.9	51.4
1973	JUN	11.9	17.7	7.14	128.9	152.2	85.7
1973	JUL	16.3	21.1	6.47	127.9	153.2	98.1
1973	AUG	15.0	19.6	6.50	109.2	134.5	81.0
1973	SEP	8.3	12.8	6.43	69.0	89.7	42.5
1973	OCT	3.6	8.0	4.97	21.7	46.2	18.1
1973	NOV	-0.9	3.2	2.54	-8.4	15.7	13.3
1973	DEC	-1.6	1.9	1.68	-17.0	10.4	10.4
1974	JAN	-9.5	-5.4	2.63	-14.6	5.9	5.9
1974	FEB	-10.4	-7.1	4.15	-14.6	2.4	2.4
1974	MAR	-6.8	-1.2	5.87	46.6	52.8	24.2
1974	APR	0.2	5.3	4.32	58.6	70.9	28.5
1974	MAY	2.2	7.8	4.82	84.7	95.3	42.9
1974	JUN	9.6	15.9	7.48	131.4	152.3	81.3
1974	JUL	12.3	17.4	6.33	118.5	139.4	81.8
1974	AUG	12.9	18.6	8.11	124.3	154.0	82.6
1974	SEP	10.7	13.6	3.95	64.5	71.5	53.4

TABLE 2.B (continued)

8202000 greenwood a 8202000 - 3
44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m
AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1974	OCT	1.8	5.8	4.82	20.8	40.2	19.4
1974	NOV	1.0	3.5	1.73	-7.4	9.9	9.9
1974	DEC	-3.5	-0.7	1.48	-16.0	4.9	4.9
1975	JAN	-7.5	-5.1	2.31	-21.3	-0.3	-0.3
1975	FEB	-9.8	-6.4	3.37	-6.6	5.0	5.0
1975	MAR	-5.4	-2.3	3.51	32.3	30.4	28.8
1975	APR	-2.6	3.2	4.63	63.1	72.1	27.0
1975	MAY	4.4	10.5	5.74	99.7	115.9	51.4
1975	JUN	8.7	15.5	8.07	138.7	159.9	82.9
1975	JUL	15.2	21.3	6.79	129.1	171.5	86.3
1975	AUG	12.2	18.0	6.95	109.6	144.4	68.0
1975	SEP	10.1	13.7	4.75	54.3	74.1	39.1
1975	OCT	3.3	7.7	5.35	24.3	48.3	18.5
1975	NOV	0.7	5.2	3.94	-11.7	17.5	9.9
1975	DEC	-6.3	-3.3	1.91	-18.4	3.2	3.2
1976	JAN	-8.4	-6.2	1.63	-24.6	-2.0	-2.0
1976	FEB	-6.4	-2.8	2.80	7.1	15.6	15.6
1976	MAR	-5.8	-0.2	5.09	38.5	52.7	18.5
1976	APR	-0.3	5.5	4.93	66.8	80.2	29.3
1976	MAY	5.4	11.5	6.84	116.5	128.0	65.3
1976	JUN	11.6	17.6	7.37	131.6	155.6	86.2
1976	JUL	13.8	18.5	7.21	133.2	146.9	100.3
1976	AUG	13.6	18.9	7.78	121.6	148.6	84.4
1976	SEP	9.6	13.6	4.98	55.8	79.2	36.7
1976	OCT	3.5	7.9	4.37	17.3	41.6	17.6
1976	NOV	-1.4	2.6	2.29	-6.0	15.7	14.9
1976	DEC	-7.1	-4.4	2.23	-21.3	0.9	0.9
1977	JAN	-9.9	-7.6	2.60	-23.4	-1.8	-1.8
1977	FEB	-7.2	-5.0	2.99	-10.5	1.7	1.7
1977	MAR	-2.5	1.0	3.84	34.9	41.5	25.0
1977	APR	-1.9	4.2	6.43	87.7	87.1	40.9
1977	MAY	3.8	10.2	7.91	132.0	133.6	74.1
1977	JUN	11.5	14.8	4.67	109.5	103.8	88.3
1977	JUL	13.0	19.0	8.82	152.4	176.0	105.9
1977	AUG	14.0	18.6	7.42	118.5	137.1	88.1
1977	SEP	8.8	12.7	5.46	60.1	78.4	40.6
1977	OCT	5.3	8.4	4.18	18.7	37.7	21.5
1977	NOV	1.9	4.6	3.63	-6.6	11.6	11.6
1977	DEC	-5.3	-2.1	1.59	-15.8	5.3	5.3
1978	JAN	-8.0	-5.8	1.55	-24.5	-1.9	-1.9
1978	FEB	-9.7	-6.8	4.22	-15.0	1.5	1.5
1978	MAR	-6.4	-2.9	5.53	44.9	36.1	34.2
1978	APR	-1.8	3.1	4.39	60.1	64.4	30.6
1978	MAY	5.2	12.2	8.03	132.9	147.5	71.9
1978	JUN	9.9	15.4	7.44	131.5	142.3	87.9
1978	JUL	12.4	18.3	7.61	136.0	162.3	90.9
1978	AUG	13.0	18.7	8.60	129.9	157.8	87.8
1978	SEP	6.0	11.2	6.81	71.4	93.6	38.0

TABLE 2.B (continued)

8202000 greenwood a 8202000 - 4
44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m
AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1978	OCT	3.8	7.4	4.32	17.7	37.8	19.9
1978	NOV	-3.0	0.2	4.27	-8.5	10.7	10.7
1978	DEC	-5.6	-3.3	1.84	-22.6	-0.3	-0.3
1979	JAN	-5.5	-3.0	1.78	-19.0	1.6	1.6
1979	FEB	-10.8	-8.0	2.92	-11.4	1.7	1.7
1979	MAR	-1.9	1.6	3.16	34.6	42.4	24.7
1979	APR	0.6	5.2	4.37	59.6	67.2	32.5
1979	MAY	7.5	12.4	4.60	83.9	102.4	50.2
1979	JUN	10.2	16.0	7.74	135.7	150.0	89.7
1979	JUL	14.3	19.7	8.04	144.5	166.6	105.5
1979	AUG	13.4	17.2	4.78	90.0	106.2	69.2
1979	SEP	9.1	13.6	7.76	81.9	98.6	53.3
1979	OCT	5.5	8.8	2.85	23.4	44.2	21.5
1979	NOV	2.8	5.9	2.57	0.1	16.6	16.6
1979	DEC	-4.8	-2.2	1.95	-18.3	2.6	2.6
1980	JAN	-8.0	-5.4	2.87	-19.5	0.7	0.7
1980	FEB	-9.5	-6.4	3.59	-8.4	4.0	4.0
1980	MAR	-5.6	-2.0	3.56	31.3	33.7	25.5
1980	APR	1.2	5.8	4.94	67.7	72.2	38.0
1980	MAY	4.1	10.1	6.11	105.4	116.4	56.4
1980	JUN	8.6	14.4	7.84	136.2	144.3	88.1
1980	JUL	14.1	18.3	5.55	110.8	126.5	84.8
1980	AUG	13.2	18.6	7.50	117.8	146.5	79.6
1980	SEP	8.1	13.0	6.35	67.7	93.7	38.3
1980	OCT	3.7	8.3	3.33	9.8	35.6	16.1
1980	NOV	-0.6	2.6	2.53	-2.0	14.1	14.1
1980	DEC	-7.6	-5.6	1.66	-26.2	-3.0	-3.0
1981	JAN	-9.8	-8.3	2.92	-24.7	-4.5	-4.5
1981	FEB	-4.0	-0.7	3.75	2.5	13.0	13.0
1981	MAR	-3.6	0.4	2.81	28.8	38.6	21.6
1981	APR	-0.1	6.0	4.85	65.4	83.3	26.4
1981	MAY	6.7	12.0	5.64	99.5	113.3	58.8
1981	JUN	10.7	15.9	7.63	135.1	142.9	94.4
1981	JUL	13.2	18.4	7.94	141.9	157.9	103.1
1981	AUG	12.4	17.2	7.92	122.2	137.4	87.7
1981	SEP	9.7	13.6	4.23	51.0	75.6	33.9
1981	OCT	3.9	7.5	4.14	16.4	36.6	19.7
1981	NOV	0.6	4.0	2.32	-3.2	15.4	15.4
1981	DEC	-1.2	0.6	1.67	-21.6	1.8	1.8
1982	JAN	-10.2	-8.2	2.35	-24.5	-3.0	-3.0
1982	FEB	-9.0	-6.0	4.44	-14.4	2.2	2.2
1982	MAR	-5.2	-1.0	5.18	40.2	43.1	27.1
1982	APR	-0.8	4.5	5.93	81.3	79.7	41.9
1982	MAY	5.0	9.8	7.23	123.3	113.4	79.7
1982	JUN	8.8	14.5	6.25	113.3	131.0	69.6
1982	JUL	13.4	19.3	9.06	155.9	178.2	110.5
1982	AUG	11.7	16.6	6.53	104.6	126.4	70.7
1982	SEP	10.9	14.5	5.81	65.7	82.0	48.6

TABLE 2.B (continued)

8202000 greenwood a 8202000 - 5

44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m

AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1982	OCT	4.1	7.9	4.79	20.9	42.7	19.7
1982	NOV	2.2	5.2	2.72	0.8	16.4	16.4
1982	DEC	-3.3	-0.4	1.59	-15.4	5.7	5.7
1983	JAN	-6.3	-3.7	2.23	-18.1	1.8	1.8
1983	FEB	-7.1	-5.1	2.75	-12.5	0.5	0.5
1983	MAR	-2.8	0.6	3.46	35.8	40.4	26.1
1983	APR	2.5	6.4	3.63	59.9	64.4	38.0
1983	MAY	7.1	11.1	5.09	92.0	93.7	63.3
1983	JUN	11.0	16.0	7.46	133.1	139.9	94.6
1983	JUL	13.7	19.0	6.85	127.7	152.7	90.1
1983	AUG	14.0	18.7	6.59	108.5	132.7	78.3
1983	SEP	10.5	16.0	7.50	79.6	114.9	44.2
1983	OCT	4.8	9.0	4.43	18.2	43.4	18.1
1983	NOV	0.8	4.4	2.73	-5.0	15.8	15.6
1983	DEC	-5.3	-2.3	2.27	-14.1	5.1	5.1
1984	JAN	-8.2	-6.0	2.37	-22.9	-1.6	-1.6
1984	FEB	-3.8	-0.9	2.45	5.4	14.4	14.4
1984	MAR	-5.2	-2.0	3.56	34.5	32.5	29.4
1984	APR	-0.1	4.5	4.64	63.6	67.2	35.0
1984	MAY	5.6	11.3	6.21	107.4	118.9	61.2
1984	JUN	10.9	15.9	7.03	126.9	136.0	89.0
1984	JUL	15.3	20.7	9.18	160.2	180.0	121.8
1984	AUG	15.9	20.5	6.84	115.0	140.7	87.3
1984	SEP	8.4	13.0	6.97	74.2	94.0	45.8
1984	OCT	4.1	8.5	4.16	15.9	41.1	17.3
1984	NOV	0.2	4.2	3.38	-13.1	14.4	10.8
1984	DEC	-3.9	-0.4	1.88	-14.2	8.0	8.0
1985	JAN	-11.3	-8.4	3.66	-28.8	-1.6	-1.6
1985	FEB	-6.9	-4.6	3.11	-8.7	2.6	2.6
1985	MAR	-6.1	-1.7	5.20	40.7	42.5	26.8
1985	APR	-2.3	3.9	6.44	88.0	86.9	40.5
1985	MAY	4.1	10.1	6.49	111.3	119.4	60.9
1985	JUN	10.8	14.8	5.51	105.1	109.3	78.1
1985	JUL	14.5	19.6	8.35	149.0	165.3	112.5
1985	AUG	12.9	17.5	7.38	116.6	132.6	85.0
1985	SEP	9.8	14.4	7.16	76.7	99.0	48.7
1985	OCT	3.8	8.5	4.54	18.3	44.9	16.8
1985	NOV	-0.4	3.1	2.22	-4.5	14.7	14.7
1985	DEC	-7.9	-5.2	2.65	-21.7	0.5	0.5
1986	JAN	-6.5	-4.0	2.48	-18.6	1.2	1.2
1986	FEB	-9.9	-6.3	4.45	-8.8	4.9	4.9
1986	MAR	-4.9	-1.4	4.93	38.2	37.2	29.7
1986	APR	2.5	6.7	4.44	61.0	68.1	36.6
1986	MAY	5.7	10.7	6.10	106.4	109.7	65.6
1986	JUN	9.0	14.9	7.36	129.6	143.5	82.1
1986	JUL	12.7	17.6	5.95	113.7	134.8	79.7
1986	AUG	13.0	16.9	5.70	96.4	110.4	73.4
1986	SEP	7.7	11.7	6.17	66.5	80.5	44.2

TABLE 2.B (continued)

8202000 greenwood a 8202000 - 6

44.98 deg. N 64.92 deg. W ELEVATION = 28.00 m

AVE. ANNUAL PRECIP. = 1099.00 mm

YEAR	MONTH	TD	T	S	NET RAD.	EVAPOTRANSPIRATION POTENT.	AREAL
1986	OCT	4.0	7.3	4.05	16.9	35.5	20.7
1986	NOV	-1.5	1.1	2.55	-1.8	11.1	11.1
1986	DEC	-6.0	-2.6	2.97	-17.3	5.1	5.1
1987	JAN	-9.1	-7.0	3.29	-23.0	-2.1	-2.1
1987	FEB	-9.9	-7.3	4.38	-16.7	0.2	0.2
1987	MAR	-5.4	-2.2	4.16	35.0	32.3	29.8
1987	APR	2.7	7.2	5.66	77.4	79.3	46.0
1987	MAY	4.2	11.2	7.34	123.1	138.3	63.2
1987	JUN	10.2	15.2	7.30	130.2	135.6	91.0
1987	JUL	13.2	19.1	8.25	145.4	171.0	100.5
1987	AUG	11.4	17.7	8.76	129.8	161.0	80.8
1987	SEP	10.5	14.6	5.73	64.1	87.1	43.0
1987	OCT	5.3	8.8	4.85	21.9	43.6	20.7
1987	NOV	-0.6	1.7	2.74	0.1	10.8	10.8
1987	DEC	-4.9	-2.6	1.71	-21.8	0.3	0.3
1988	JAN	-7.6	-5.5	2.65	-22.5	-1.6	-1.6
1988	FEB	-7.8	-5.3	4.34	-14.6	1.4	1.4
1988	MAR	-4.9	-0.2	4.89	36.8	46.9	21.9
1988	APR	0.7	4.4	3.51	59.6	58.2	38.5
1988	MAY	6.4	12.1	7.10	120.8	128.7	72.6
1988	JUN	9.0	14.7	6.92	123.4	137.3	78.3
1988	JUL	15.5	19.9	5.76	116.5	137.2	89.9
1988	AUG	15.6	19.8	6.13	106.3	128.0	82.5
1988	SEP	8.3	12.4	5.93	64.4	82.1	42.1
1988	OCT	4.1	7.4	4.40	18.6	37.3	21.0
1988	NOV	1.4	5.1	3.79	-11.5	14.4	11.9
1988	DEC	-6.9	-4.1	2.69	-19.0	2.0	2.0
1989	JAN	-7.3	-4.8	2.29	-20.5	0.4	0.4
1989	FEB	-8.4	-6.3	2.84	-13.1	0.2	0.2
1989	MAR	-6.1	-3.3	5.26	20.2	22.2	22.2
1989	APR	0.3	4.7	5.60	77.1	71.8	45.2
1989	MAY	8.7	14.5	6.34	110.8	132.9	65.7
1989	JUN	11.8	16.7	6.61	122.0	134.7	86.6
1989	JUL	12.6	18.4	8.37	146.4	167.7	101.4
1989	AUG	13.6	19.2	8.18	125.9	155.9	85.8
1989	SEP	9.6	14.4	7.03	75.2	100.3	45.7

TABLE 2.B (continued)

APPENDIX C

SHEFFIELD FARM RECONNAISSANCE
HYDROMETRIC GAUGING STATION
AND SOME OBSERVATIONS
FOR MODEL VERIFICATION

Sheffield Farm Reconnaissance
Hydrometric Gauging Station
And Some Observations
For Model Verification

Many variables are needed in the water balance equation, e.g., streamflow, precipitation, evapotranspiration, ground water storage, etc. Streamflow data is one of the easiest to monitor and also one of the most vital of parameters in the equation. Hence, a water balance model used to estimate a basin's water budget should be verified with at least measured streamflow data.

The nearest active hydrometric station to the study area is Sharpe Brook. If this site is deemed necessary for a water balance estimate of the Sheffield Farm basin there are a number of negative restrictions to be addressed. The drainage area of Sharpe Brook is roughly four times larger than the study area. This parameter is important if used in the proration process. A drainage area difference of more than 25% can lead to gross errors in any water balance estimate. Also, the Sharpe Brook station is approximately 17 kilometres away from the study area, hence, the precipitation pattern may differ. The physiography of the areas are quite different, i.e., surface cover, land contours, drainage area shape, etc. Also the Sheffield Farm basin is regulated.

A reconnaissance survey of the Sheffield Farm study area, for a possible hydrometric site, was completed in the fall of 1989. A hydrometric gauging site was found approximately 1.5 kilometres downstream of the dam at the artificial pond. Although the drainage area at the hydrometric site is twice that at the dam site, this should not be a major problem. The climatic and physiographic parameters would be quite similar at both locations. But, not being fully aware of the research expectations of this project, and from a hydrometric point of view only, this site is not truly satisfactory.

A staff gauge has been installed at this site and a stage/discharge relationship is been developed. The drainage area of this basin was delineated on 1:10,000 scale topographic maps of the area.

SOME APPROXIMATE STATISTICS

LOCATION	DRAINAGE AREA (km^2)	DISTANCE FROM DAM (km)
Sheffield Farm	2	-
Temporary Hydrometric Site	5.33	1.5
Sharpe Brook Gauging Site	8.81	17